



## DECLARATION

I, Shinichi KAWASAKI of Room 704, 17-34, Miyadacho 2-chome, Takatsuki-shi, Osaka 569-1142 Japan hereby declare that I am conversant with the Japanese language and that I am the translator of the document attached and certify that to the best of my knowledge and belief the following is a true and correct English translation of the specification contained in the Priority Document No. 2001-368291.

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S. Kawasaki

Shinichi KAWASAKI

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(Translation)

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[INVENTOR]  
[DOMICILE OR RESIDENCE] c/o Matsushita Electric Industrial Co., Ltd.  
[NAME] 1006, Oaza-Kadoma, Kadoma-shi, Osaka  
Tetsu HASHIMOTO  
[INVENTOR]  
[DOMICILE OR RESIDENCE] c/o Matsushita Electric Industrial Co., Ltd.  
[NAME] 1006, Oaza-Kadoma, Kadoma-shi, Osaka  
Futoshi TANIGAWA  
[INVENTOR]  
[DOMICILE OR RESIDENCE] c/o Matsushita Electric Industrial Co., Ltd.  
[NAME] 1006, Oaza-Kadoma, Kadoma-shi, Osaka  
Naoto ARAI  
[PATENT APPLICANT]  
[ID NUMBER] 000005821  
[NAME OR CORPORATE NAME] Matsushita Electric Industrial Co., Ltd.  
[ATTORNEY]  
[ID NUMBER] 100097445  
[PATENT ATTORNEY]  
[NAME OR CORPORATE NAME] Fumio IWASHI  
[SELECTED ATTORNEY]  
[ID NUMBER] 100103355  
[PATENT ATTORNEY]  
[NAME OR CORPORATE NAME] Tomoyasu SAKAGUCHI  
[SELECTED ATTORNEY]  
[ID NUMBER] 100109667

[PATENT ATTORNEY]

[NAME OR  
CORPORATE NAME] Hiroki NAITO

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(Translation)

[DOCUMENT NAME] Specification

[TITLE OF THE INVENTION] SECONDARY BATTERY

[CLAIMS]

[Claim 1] A secondary battery in which a positive electrode plate manufactured by applying a positive electrode material to a positive electrode current collector and a negative electrode plate manufactured by applying a negative electrode material to a negative electrode current collector are wound interposing a separator to fabricate an electrode plate group, and in which said electrode plate group is housed in a battery case together with an electrolyte,

characterized in that an unapplied portion is provided at an end portion of at least one of the positive electrode plate and the negative electrode plate in said electrode plate group, and said unapplied portion is projected from said electrode plate group to directly connect with a current collecting plate, and

a convex part is formed on said current collecting plate, said convex part being fitted in a hole opened at a bottom of said battery case, and said fitted part being welded to be sealed.

[Claim 2] The secondary battery in accordance with claim 1, wherein said battery is a non-aqueous electrolyte secondary battery.

## [DETAILED DESCRIPTION OF THE INVENTION]

[0001]

## [Technical Field to Which the Invention Belongs]

The present invention relates to a secondary battery, especially to a current collecting structure.

[0002]

## [Prior Art]

In recent years, electronic devices such as AV equipment and personal computers are becoming portable and wireless at a rapid pace. As a power source for them, there is a growing demand for a compact and lightweight secondary battery having high energy density. In particular, a lithium ion secondary battery using lithium as an active material is greatly expected as a battery showing high voltage and high energy density. Further, a secondary battery for power tools is required to be high-powered.

[0003]

To meet the above-mentioned demands, it is important to reduce an internal resistance of a battery. In a common lithium ion secondary battery, electric current is collected from a positive electrode plate and a negative electrode plate via leads, respectively. Regarding a high-powered lithium ion secondary battery, on the other hand, there has been proposed a method of collecting the electric current by projecting ends of the positive and negative electrode plates from the group, and welding current collecting plates thereto as recited in

Japanese Laid-Open Patent Publication No. 2000-294222.

According to this current collecting method, the resistance can be reduced as compared with use of the leads.

[0004]

In general, welding of the lead from the electrode plate or the connector piece from the current collecting plate to the battery case is carried out by making use of a hollow part defined as a winding core of the electrode group. There has been a method of spot-welding them by using a welding rod or irradiating a laser beam or an electron beam through the hollow. On the other hand, there has also been proposed a spot-welding method by irradiating a laser beam or an electron beam from outside the battery case, as recited in Japanese Patent Publication No. 2937456.

[0005]

[Problem That the Invention Is to Solve]

However, in the conventional method of resistance-welding the negative electrode current collector and the bottom of the battery by inserting the welding rod into the winding core, improvement in capacity based on the reduction of the hollow in the winding core is not expected, since reduction of the diameter of the welding rod is limited. Moreover, entanglement of the separator occurs when the welding rod is inserted, which may cause failure.

[0006]

In the case of performing the laser-welding from the

bottom of battery case, because a gap is prone to be formed between the negative electrode current collector and the battery can, the welding strength is apt to vary. To eliminate the gap, pressure needs to be applied from above to the electrode group. However, this may cause failure such as buckling of the electrode plates.

[0007]

The present invention is made in light of the above conventional problems, and aims to provide a current collecting structure with a securely welded current collector at the bottom, even though the winding core is made small to improve the battery capacity.

[0008]

[Means for Solving the Problem]

In order to achieve the above aims, in the present invention, a hole is provided at the bottom of the battery case, and a convex part is formed at the current collecting plate. The convex part is fitted to the hole opened at the bottom of the battery case, and the fitted part is sealed by welding.

[0009]

Such welding can be carried out from outside the battery case. Therefore, the welding state can be visually checked directly. This makes possible to realize a current collecting structure in which the current collector is surely welded to the bottom of the battery case without use of the

welding rod.

[0010]

[Mode for Embodying the Invention]

In a secondary battery of the present invention, a positive electrode plate manufactured by applying a positive electrode material to a positive electrode current collector and a negative electrode plate manufactured by applying a negative electrode material to a negative electrode current collector are wound interposing a separator to fabricate an electrode plate group, and the electrode plate group is housed in a battery case together with an electrolyte,

characterized in that an unapplied portion is provided at an end portion of at least one of the positive electrode plate and the negative electrode plate in the electrode plate group, and the unapplied portion is projected from the electrode plate group to directly connect with the current collecting plate, and

a convex part is formed on the current collecting plate, the convex part being fitted in a hole made at the bottom of the battery case, and the fitted part being welded to be sealed. The effect of the invention is that the current collector is securely welded at the bottom part of the battery.

[0011]

It is preferable that the seam welding using a laser is used in view of workability, although a known welding method can be used.

[0012]

It is preferable that the convex part is in the form that easily fills the hole formed at the bottom of the battery case. The convex part is preferably in such a shape that the width increases from a distal end to a proximal part while maintaining the cross sections geometrically similar.

[0013]

Although the secondary battery of the present invention can be applied to well-known secondary batteries such as a nickel-cadmium storage battery and a nickel-metal hydride storage battery, it is especially preferable for a lithium ion secondary battery which can achieve a thin electrode plate and a small winding core.

[0014]

Hereinafter, a lithium ion secondary battery as an embodiment of the secondary battery of the present invention is specifically described by referring to FIG.1.

[0015]

In FIG. 1, a positive electrode 1 and a negative electrode 2 are wound in a spiral fashion facing each other with the interposition of a separator 3 made of a fine porous polyethylene film to form an electrode group 10. The electrode plate group 10 is stored in a battery case 4 together with an electrolyte. The battery case 4 is composed of a battery can 5 with a cylindrical container shape to be served as a negative electrode terminal, and a battery lid 6

to serve as a positive electrode terminal. An insulating packing 7 interposed between the upper end of the inner periphery of an opening of the battery can 5 and the outer periphery of the battery lid 6 is insulating the can 5 and the lid 6 from each other, while sealing the battery case 4. The separator 3 is also interposed between the electrode plate group 10 and the inner periphery of the battery can 5.

[0016]

The positive electrode 1 is formed by applying a positive electrode material 1a on both sides of a positive electrode current collector 1b, and one end (upper end in the example shown in the figure) of the positive electrode current collector 1b is projecting more than the part where the positive electrode material 1a is applied. Additionally, a negative electrode plate 2 is formed by applying a negative electrode material 2a on both sides of a negative electrode current collector 2b. The other end (lower end in the example shown in the figure) of the negative electrode current collector 2b is projecting more than the part where the negative electrode material 2a is applied. A separator 3 is projecting more than both ends of the applied part of the positive electrode plate 1 and the negative electrode plate 2.

[0017]

Then, a positive electrode flat portion 11 is formed by deforming the part of the positive electrode current collector 1b projecting more than the separator 3, and a

positive electrode current collecting plate 8 is connected to the flat portion 11. Similarly, a negative electrode flat portion 12 is formed by deforming the part of the negative electrode current collector 2b projecting more than the separator 3, and a negative electrode current collecting plate 9 is connected to the flat portion 12.

[0018]

These positive electrode current collecting plate 8 and negative electrode current collecting plate 9 are connected to a battery lid 6 and a battery can 5, respectively. A connecting piece 8a is extended from the periphery of the positive electrode current collecting plate 8 to connect the positive electrode current collecting plate 8 with the inner side of the battery lid 6. Then, a convex part 9 is formed on the negative electrode current collecting plate 9 to fit in a hole 13 opened at the bottom. The fitted part is seam-welded by a laser.

[0019]

This battery has a diameter of 18 mm, a height of 65 mm, and a capacity of 1200 mAh. The thickness of the battery can 5 is 0.5 mm, and the diameter of the hole 13 is 3 mm. The thickness of the current collecting plates 8 and 9 is 0.2 mm, and the convex part 9a has a diameter of 2.5 mm at the tip, and a diameter of 3.5 mm at the root, and has a height of 1 mm.

[0020]

The manufacturing method is shown concretely next. For the positive electrode plate 1, a positive electrode active material  $\text{LiMn}_2\text{O}_4$  manufactured by mixing electrolytic manganese dioxide (EMD:  $\text{MnO}_2$ ) and lithium carbonate ( $\text{Li}_2\text{CO}_3$ ) to satisfy  $\text{Li/Mn}=1/2$  and then baking the mixture in the atmosphere for 20 hours at 800 °C, acetylene black as a conductive agent, and polyvinylidene fluoride as a binder were mixed in a weight ratio of 92:3:5 to serve as a positive electrode material 1a.

[0021]

For the polyvinylidene fluoride as the binder, a dispersion of the same in N-methylpyrrolidone was used to knead the positive electrode material 1a to become a paste. The above mixing ratio was the ratio for solid matter. A positive electrode material layer was formed by applying the positive electrode material paste to both sides of the positive electrode current collector 1b comprising an aluminum foil with a thickness of 20  $\mu\text{m}$ , leaving an unapplied portion with a width of 6.5 mm on one end thereof. The both thicknesses of the positive electrode material layers were the same. The total of both layers after drying was 280  $\mu\text{m}$ , and the thickness of the positive electrode plate was 300  $\mu\text{m}$ . Afterwards, the positive electrode plate 1 was compressed by a press-roller with a diameter of 300 mm, to have a thickness of 200  $\mu\text{m}$ . At this time, the density of the positive electrode material was 3.0  $\text{g}/\text{cm}^3$ .

[0022]

Artificial graphite, and styrene-butadiene rubber (SBR) as a binder were mixed in a ratio of 97:3 by weight to prepare a negative electrode material 12a. Styrene-butadiene rubber as the binder was used in a dispersed state in water to obtain the negative electrode material 2a in paste form. The above-described mixing ratio was the ratio for solid matter. The negative electrode material mixture paste was applied to both surfaces of a negative electrode current collector 2b made of a copper foil of 14  $\mu\text{m}$  thick to form negative electrode material layers, leaving an unapplied portion with a width of 4 mm in one end portion. Afterwards, the negative electrode plate 2 was compressed with a press-roller of 300 mm in diameter to become a thickness of 170  $\mu\text{m}$ . The density of negative electrode material at this time was 1.4 g/cm<sup>3</sup>.

[0023]

To prepare an electrolyte, lithium hexafluorophosphate (LiPF<sub>6</sub>) as a solute was dissolved with a concentration of 1 mol/dm<sup>3</sup> in a mixture solvent of ethylene carbonate (EC) and diethyl carbonate (DEC) mixed in a ratio of 1:1 by volume.

[0024]

In manufacturing this lithium ion secondary battery, an electrode plate group 10 was formed by facing a positive electrode plate 1 and a negative electrode plate 2 interposing a separator 3 and wound in a spiral fashion while projected

portions of current collectors 1b and 2b are being protruded on both ends. The length of the projected portion was set to become 2 mm.

[0025]

Flat portions 11 and 12 were made by bending core materials of the projected portions of this electrode plate group 10.

[0026]

Then, to the electrode plate group 10 in which flat portions 11 and 12 were formed, current collecting plates 8 and 9 were disposed so that the current collecting plates 8 and 9 were pressed onto the flat portions 11 and 12. While the current collecting plates 8 and 9, and flat portions 11 and 12 were press-contacted, the current collecting plates 8 and 9, and flat portions 11 and 12 were laser-welded by applying a laser beam radially from the center to the peripheral edge of the current collector plates 8 and 9, on a plurality of spots to the circumferential directions. Then, the electrode plate group 10 to which the current collecting plates 8 and 9 were connected was housed in the battery can 5, and a convex part 9a was fitted into a hole 13 of the bottom, to be seam-welded by a laser.

[0027]

Then, a connecting piece 8a and the battery lid 6 were connected respectively by a laser-welding and the like. The electrolyte was charged by a vacuum-impregnation, and the

battery lid 6 was provided for sealing.

[0028]

The average value of the welding strength among 100 fabricated cylindrical batteries was 18.5 kg/cm<sup>2</sup> and the standard deviation (value  $\sigma$ ) was 0.9 kg/cm<sup>2</sup>. These values are practically effective as compared with a conventional resistance welding process and the like.

[0029]

In the case of welding the bottom to a battery of this size using a conventional welding rod, the winding core needs to have a diameter of at least about 3.5 mm to carry out the welding with reliability. However, in the secondary battery of the present invention, the diameter of the winding core can be reduced to become as small as about 0.5 mm. Thus, capacity improvement was achieved by about 4 % on a volume basis.

[0030]

#### [Effects of the Invention]

According to the secondary battery of the present invention, a current collecting structure in which a current collector is welded securely at the bottom is easily realized. Further, since the volume of the winding core of the battery is reduced, such volume is effectively utilized to increase the capacity.

#### [BRIEF EXPLANATION OF THE DRAWINGS]

[FIG.1]

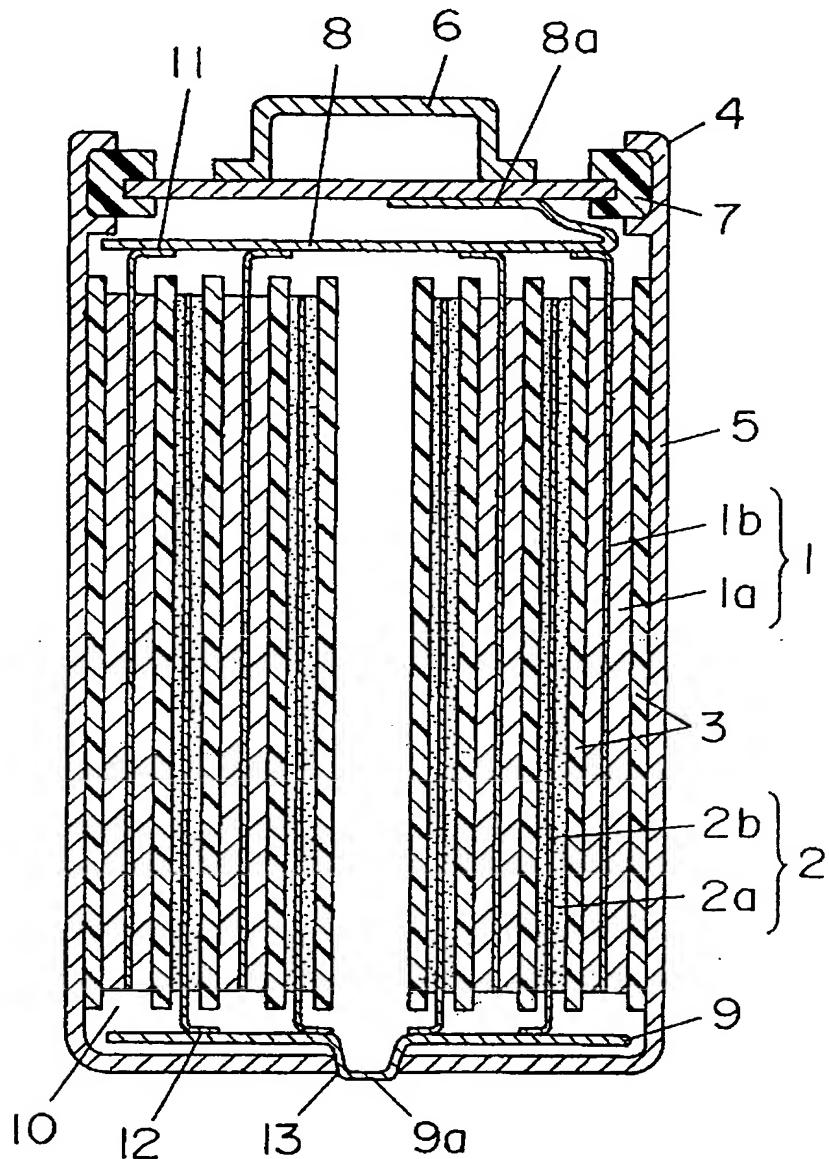
A vertical cross section of a lithium ion secondary battery according to an embodiment of the present invention.

[Explanation of Reference Numerals]

- 1 Positive Electrode
- 1a Positive Electrode Material
- 1b Positive Electrode Current Collector
- 2 Negative Electrode Plate
- 2a Negative Electrode Material
- 2b Negative Electrode Current Collector
- 3 Separator
- 4 Battery Case
- 5 Battery Can
- 6 Battery Lid
- 7 Insulating Packing
- 8 Positive Electrode Current Collecting Plate
- 8a Positive Electrode Connecting Piece
- 9 Negative Electrode Current Collecting Plate
- 9a Convex Part
- 10 Electrode Plate Group
- 11 Positive Electrode Flat Portion
- 12 Negative Electrode Flat Portion
- 13 Hole

【書類名】 図面 [DOCUMENT NAME] Drawings

【図1】 [FIG. 1]



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(Translation)

[DOCUMENT NAME] Abstract

[ABSTRACT]

[OBJECTIVE] To provide a secondary battery capable of having a current collecting structure in which a current collector is welded securely to the bottom part, even though the secondary battery had a small winding core to improve a battery capacity.

[SOLVING MEANS] In a secondary battery in which a battery case housing a wound electrode plate group and a current collector are connected: the battery case has a hole at the bottom thereof; a convex part is formed in a current collecting plate; the convex part is fitted into the hole opened at the bottom of the battery case; and the fitted part is sealed by a welding.

[SELECTED DRAWING] FIG. 1

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